

1 CLAIMS:

2 1. A semiconductor processing method of cleaning a surface of
3 a copper-containing material, comprising:

4 forming the copper-containing material over a semiconductor
5 substrate; and

6 exposing the surface of the copper-containing material to an acidic
7 mixture comprising Cl^- , NO_3^- and F^- .

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9 2. The method of claim 1 wherein the copper-containing
10 material consists essentially of copper.

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12 3. The method of claim 1 wherein the mixture is an aqueous
13 mixture comprising non-aqueous components, and wherein the non-
14 aqueous components consist essentially of Cl^- , NO_3^- , F^- , at least until the
15 exposing.

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17 4. The method of claim 1 wherein the mixture is an aqueous
18 mixture and wherein the only non-hydroxide anions in the mixture consist
19 essentially of Cl^- , NO_3^- and F^- , at least until the exposing.

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21 5. The method of claim 1 wherein the exposing occurs for a
22 time of from about 30 seconds to about 1 hour.

1 6. The method of claim 1 wherein the exposing removes one
2 or more of a copper oxide, a silicon oxide and a copper fluoride from
3 on the surface.

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5 7. The method of claim 1 wherein the exposing occurs at a
6 temperature of from about 10°C to about 40°C.

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8 8. A method of cleaning a surface of a copper-containing
9 material, comprising:

10 forming the copper-containing material over a semiconductor
11 substrate; and

12 exposing the surface of the copper-containing material to a cleaning
13 solution formed from hydrochloric acid, nitric acid and hydrofluoric acid.

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15 9. The method of claim 8 wherein the cleaning solution consists
16 essentially of Cl^- , NO_3^- , F^- and equilibrium components of H_3O^+ and
17 H_2O , at least until the exposing.

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19 10. The method of claim 8 wherein the mixture is an aqueous
20 mixture and wherein the only non-hydroxide anions in the cleaning
21 solution consist essentially of Cl^- , NO_3^- and F^- , at least until the
22 exposing.

1 11. The method of claim 8 further comprising, before the
2 exposing, forming the cleaning solution by combining an HCl solution
3 (36%, by weight in water), an HF solution (49%, by weight in water),
4 an HNO₃ solution (70%, by weight in water) and H₂O; the relative
5 amounts of the combined H₂O and solutions being:

6 from about 2.5 parts H₂O per 1 part HCl solution to about 10
7 parts H₂O per 1 part HCl solution;

8 from about 75 parts H₂O per 1 part HNO₃ solution to about 300
9 parts H₂O per 1 part HNO₃ solution; and

10 from about 150 parts H₂O per 1 part HF solution to about 600
11 parts H₂O per 1 part HF solution.

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13 12. The method of claim 8 further comprising, before the
14 exposing, forming the cleaning solution by combining H₂O with solutions
15 of HCl (36%, by weight in water), HF (49%, by weight in water) and
16 HNO₃ (70%, by weight in water); the relative amounts of the combined
17 H₂O and solutions being about 300 parts H₂O; about 60 parts of the
18 HCl solution; about 2 parts of the HNO₃ solution; and about 1 part of
19 the HF solution.

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21 13. The method of claim 8 wherein the exposing removes one
22 or more of a copper oxide and a copper fluoride from on the surface.
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1 14. A semiconductor processing method of forming an opening
2 to a copper-containing substrate, comprising:

3 providing a copper-containing substrate having a mass thereover,
4 the mass comprising at least one of a silicon nitride and a silicon oxide,
5 the copper-containing substrate being supported by a semiconductor
6 material;

7 etching an opening through the mass and to the copper-containing
8 substrate, a surface of the copper-containing substrate forming a base of
9 the opening and thus defining a base surface of the opening, said base
10 surface being at least partially covered by at least one of a copper
11 oxide, a silicon oxide or a copper fluoride; and

12 cleaning said base surface with an acidic mixture comprising Cl^- ,
13 NO_3^- and F^- to remove at least some of the at least one of a copper
14 oxide, a silicon oxide or a copper fluoride from the base surface.

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16 15. The method of claim 14 wherein the mass comprises at least
17 two layers stacked atop one another, one of the at least two layers
18 comprising the silicon oxide and the other of the at least two layers
19 comprising the silicon nitride; and wherein the opening is etched through
20 both of the at least two layers.

1 16. The method of claim 14 wherein the base surface is at least
2 partially covered by copper oxide, silicon oxide and copper fluoride; and
3 wherein the cleaning removes substantially all of the copper oxide, silicon
4 oxide and copper fluoride from the base surface of the copper-containing
5 substrate.

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7 17. The method of claim 14 wherein the copper-containing
8 substrate consists essentially of elemental copper.

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10 18. The method of claim 14 wherein the mixture is an aqueous
11 mixture comprising non-aqueous components, and wherein the non-
12 aqueous components consist essentially of Cl^- , NO_3^- , F^- , at least until the
13 exposing.

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15 19. The method of claim 14 wherein the mixture is an aqueous
16 mixture and wherein the only non-hydroxide anions in the mixture consist
17 essentially of Cl^- , NO_3^- and F^- , at least until the exposing.

1 20. A semiconductor processing method of forming an opening
2 to a copper-containing substrate, comprising:

3 providing a copper-containing substrate having a mass thereover,
4 the mass comprising at least one of a silicon nitride and a silicon oxide,
5 the copper-containing substrate being supported by a semiconductor
6 material;

7 etching an opening through the mass and to the copper-containing
8 substrate, a surface of the copper-containing substrate forming a base of
9 the opening and thus defining a base surface of the opening, said base
10 surface being at least partially covered by at least one of a copper
11 oxide, a silicon oxide or a copper fluoride; and

12 cleaning said base surface with a cleaning solution formed from
13 hydrochloric acid, nitric acid and hydrofluoric acid to remove at least
14 some of the at least one of a copper oxide, a silicon oxide or a copper
15 fluoride from the base surface.

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17 21. The method of claim 20 wherein the mass comprises at least
18 two layers stacked atop one another, one of the at least two layers
19 comprising the silicon oxide and the other of the at least two layers
20 comprising the silicon nitride; and wherein the opening is etched through
21 both of the at least two layers.
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1 22. The method of claim 20 wherein the base surface is at least
2 partially covered by copper oxide, silicon oxide and copper fluoride; and
3 wherein the cleaning removes substantially all of the copper oxide, silicon
4 oxide and copper fluoride from the base surface of the copper-containing
5 substrate.

6
7 23. The method of claim 20 wherein the copper-containing
8 substrate consists essentially of elemental copper.

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10 24. The method of claim 20 wherein the cleaning solution
11 consists essentially of Cl^- , NO_3^- , F^- and equilibrium forms of H_3O^+ and
12 H_2O , at least until the exposing.

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14 25. The method of claim 20 wherein the mixture is an aqueous
15 mixture and wherein the only non-hydroxide anions in the cleaning
16 solution consist essentially of Cl^- , NO_3^- and F^- , at least until the
17 exposing.

1 26. The method of claim 20 further comprising, before the
2 exposing, forming the cleaning solution by combining an HCl solution
3 (36%, by weight in water), an HF solution (49%, by weight in water),
4 an HNO₃ solution (70%, by weight in water) and H₂O; the relative
5 amounts of the combined solutions and H₂O being:

6 from about 2.5 parts H₂O per 1 part HCl solution to about 10
7 parts H₂O per 1 part HCl solution;

8 from about 75 parts H₂O per 1 part HNO₃ solution to about 300
9 parts H₂O per 1 part HNO₃ solution; and

10 from about 150 parts H₂O per 1 part HF solution to about 600
11 parts H₂O per 1 part HF solution.